

GUIDELINES FOR SLEEP STUDIES IN ADULTS

Prepared for the

Australasian Sleep Association

&

Thoracic Society of Australia and New Zealand

by

Hensley MJ, Hillman DR, McEvoy RD (Chair), Neill AM, Solin P,
Teichtahl H, Thompson BR, Tolhurst S, Thornton AT, Worsnop CJ.

October 2005

(Paediatric representatives to the committee, Drs M. Davey and G. Cooper, contributed to the early discussions but otherwise did not take part in the formulation of these guidelines. Separate guidelines for paediatric sleep studies are to be prepared.)

TABLE OF CONTENTS

	PAGE
Executive Summary	3
1. INTRODUCTION	5
2. RESPIRATORY SLEEP DISORDERS	6
2.1 Preamble	6
2.2 Indications for sleep study	6
2.3 Types of respiratory sleep study	10
2.4 Choosing the type of respiratory sleep study	12
2.5 Preparations and instructions to patients	16
2.6 Measurement techniques	17
2.7 Recording and analysis	22
2.8 Laboratory report	27
3. MOVEMENT AND BEHAVIOURAL DISORDERS OF SLEEP	27
3.1 Indications for sleep study	27
3.2 Types of sleep study	28
4. NON RESPIRATORY DISORDERS OF EXCESSIVE DAYTIME SLEEPINESS	29
4.1 Indications for sleep study	29
4.2 Types of sleep study	30
4.3 Test performance and interpretation	31
5. INSOMNIA AND DISORDERS OF INSUFFICIENT SLEEP	32
5.1 Indications for sleep study	32
5.2 Sleep diary and actigraphy	32
6. SLEEP LABORATORY FACILITIES AND PERSONNEL REQUIREMENTS	32
7. REFERENCE LIST	33
8. APPENDIX	38

EXECUTIVE SUMMARY

INTRODUCTION

This a consensus statement by a committee of experienced sleep practitioners and scientists on the indications and performance of sleep studies in adults. The report is not a formal evidenced-based review of sleep studies but it does draw significantly from several recent reviews of this type, which are referenced throughout the document. The committee was empanelled by the Australasian Sleep Association and the Thoracic Society of Australia and New Zealand. Individual conflicts of interest were declared before the review began and are outlined in an appendix. Individual COI statements were vetted by the ASA and TSANZ executives and were declared to all other committee members.

The report highlights the expanding and evolving nature of sleep investigations. It stresses the central role of the expert clinician in establishing the indications for sleep investigations and in the interpretation of sleep study results. A major concern regarding the performance of sleep studies is the lack of uniformity of definitions (eg of abnormal breathing events) and of quality standards between sleep-centres. This document seeks to improve standards within Australian and New Zealand by encouraging an evidenced-based approach to the performance of sleep testing, by promoting an internationally accepted and uniform set of definitions of sleep disordered breathing and by encouraging a high standard of laboratory quality control. Detailed guidelines are provided on indications for sleep studies and the methods for performing and reporting the studies.

The statement substantially revises and extends the 1994 TSANZ/ ASA report on Respiratory Sleep Studies. The key changes are:

1. A recommendation that Australian and New Zealand sleep laboratories adopt the “Chicago criteria” for the measurement and scoring of abnormal respiratory events. This includes adoption of nasal pressure as the primary method for detecting airflow and of the more sensitive Chicago definition of a hypopnea or partial obstructive event.
2. An extensively revised and expanded section on limited channel or “screening” sleep apnea monitors designed for use at home. The committee
 - a. Concurs with the main finding from a recent North American evidenced based review (to which the ASA actively contributed) and accompanying professional statements, namely, that there is presently insufficient data on the reliability of these devices to recommend their general use for the diagnosis of sleep apnea in the home. However, it
 - b. Notes that some multi-channel respiratory monitors have good diagnostic accuracy (to both “rule-in” and “rule-out” OSA) in an *attended* setting and thus may be a useful adjunct to PSG in

sleep laboratories where access to full sleep studies is limited. Further, it

- c. Notes evidence supporting the use at home of some single or multi-channel monitors to “rule-in” (but not “rule-out”) sleep apnea. Such devices may therefore prove useful in high-prevalence sleep apnea populations where laboratory resources are limited (eg to fast track the management of severe cases or prioritise sleep laboratory waiting lists). However, it
 - d. Recommends that home diagnostic monitoring devices be used only under the supervision of an accredited sleep physician who has a sound knowledge of their technical and diagnostic capabilities and limitations and in a setting where there is access to polysomnography (PSG).
3. Guidelines on the indications and performance of sleep studies in non-respiratory sleep disorders. Specifically, the committee recommends that
- a. PSG not be used for the routine assessment of insomnia, periodic limb movement disorder, restless legs syndrome or parasomnias if one of these is considered the likely primary abnormality. Such conditions are usually diagnosed with confidence following careful history and examination. However,
 - b. PSG be considered if there is a suspicion of overlapping disorders (eg co-existing sleep disordered breathing) or if, following careful clinical assessment, there is doubt about the diagnosis.
 - c. An expanded EEG and EMG montage plus continuous video recording are employed in cases of sleep movements or behaviours that are violent or potentially dangerous, or where there is diagnostic uncertainty. These additional measurements can be helpful in distinguishing between complex partial seizures, REM behaviour disorder and NREM parasomnias, and thus aid in directing appropriate therapy.
 - d. PSG be performed in all cases of suspected primary hypersomnia or narcolepsy to rule out co-existing disorders such as OSA that can lead, or contribute, to daytime sleepiness.
 - e. The multiple sleep latency test (MSLT) is used as an aid in the diagnosis of patients suspected of narcolepsy.
 - f. Daytime tests which assess the ability to resist sleep such as the maintenance of wakefulness test (MWT) may be helpful in the management of sleepy patients, particularly for medicolegal purposes or where there is a discrepancy between PSG findings and symptoms.

1. INTRODUCTION

These guidelines have been developed by a committee empanelled by the Thoracic Society of Australia and New Zealand and the Australasian Sleep Association. The Committee has done everything to ensure that the guidelines are objective and evidence-based using the current literature, supplemented by expert opinion. The recommendations are not all high level evidence: wherever available, systematic reviews (1-6) and randomised controlled trials have been used. They are intended to practically guide clinical practice rather than act as absolute standards. They will require further modification as knowledge and technology continue to evolve.

The previous edition of these guidelines(7) focused exclusively on respiratory sleep studies. By far the majority of sleep studies continue to be performed to assist in the diagnosis and management of respiratory sleep disorders. However, an increasing number of patients are referred to sleep disorders clinics with non-respiratory disorders such as insomnia, parasomnias, narcolepsy or overlapping respiratory and non-respiratory syndromes. Some of these disorders require specialised sleep investigations to assist in their proper identification and management. Thus, while most of this document is devoted to the various tests used to assess obstructive sleep apnoea and associated sleep breathing disorders it has been expanded to consider non respiratory sleep disorders as well. The document examines the indications and standards for sleep studies under the following headings:

- Respiratory Sleep Disorders
- Movement and Behavioural Sleep Disorders
- Non-respiratory Disorders of Excessive Daytime Sleepiness
- Insomnia and Other Disorders Characterised by Insufficient Sleep

The need for common definitions and diagnostic methodologies has become evident, for both clinical and research purposes, particularly in the measurement of respiratory sleep disorders. A recent task force report has provided useful guidance (8) and its recommendations have been incorporated into this document wherever possible in an effort to achieve consistency with international benchmarks.

It is evident that the burden of disease associated with sleep disorders is great, given their high prevalence and significant associated morbidities. There is pressure on specialized facilities throughout Australia and New Zealand as they meet growing demands for diagnosis and treatment. This is driving a continuing search for methods to reduce the costs and/or increase the availability of investigation of these problems (9;10). These guidelines examine the available types of sleep study including alternatives to traditional laboratory-based polysomnography, relevant measurement techniques, interpretative criteria, and standards for investigative facilities.

2. RESPIRATORY SLEEP DISORDERS

2.1 PREAMBLE

Historically, an important problem with respiratory sleep studies has been the lack of agreement on recording methods and on definitions of abnormal respiratory events. In 1999, evidenced based guidelines on respiratory sleep recording methods and criteria for the scoring of respiratory events were published by the American Academy of Sleep Medicine (8). These are commonly known as the “Chicago” recommendations. It was believed that improved diagnostic reproducibility between research and clinical centres would flow from these recommendations. However, as evidenced by a recent report of practises amongst Australian centres, clinically important discrepancies continue between sleep laboratories (11). The present guidelines have incorporated the 1999 “Chicago” recommendations in the hope that this will lead to improved diagnostic accuracy and reliability between and within sleep investigation facilities in Australia and New Zealand.

An area of ongoing debate and controversy is the role of home sleep study monitors in the assessment of patients with sleep-disordered breathing. Limitation of resources relative to demand and cost are major factors necessitating consideration of other types of sleep study to replace traditional attended polysomnography. The range and technical sophistication of portable sleep study devices continues to increase. They have the potential to increase patient access to diagnostic and therapeutic services at lower cost and they are actively promoted by diagnostic and therapeutic equipment manufacturers. Unfortunately, however, well-designed studies demonstrating the effectiveness and cost effectiveness of these devices are frequently lacking or lag substantially behind their promotion. The current guidelines draw significantly on a recent evidenced based review of home diagnostic sleep studies (3), other recent relevant RCT findings plus the authors’ own expert opinions. Thus while this document continues to focus on the indications and conduct of the “gold standard” PSG the recommendations should also provide practitioners in Australia and New Zealand with a practical and balanced perspective on the use of portable sleep study devices in 2005. This is an area that is likely to evolve rapidly over the next 5-10 years and current recommendations will undoubtedly require revision as further high-quality studies are reported.

2.2 INDICATIONS FOR SLEEP STUDY

There are three broad indications for respiratory sleep studies:

- 2.2.1 Diagnostic studies: to aid making a diagnosis
- 2.2.2 Intervention studies: to implement and titrate, or confirm effectiveness of a new treatment
- 2.2.3 Follow-up studies: to follow the progress of a patient.

2.2.1 DIAGNOSTIC STUDIES

Diagnostic studies are performed to identify and quantify:

- 2.2.1.1 suspected obstructive sleep apnoea (OSA)
- 2.2.1.2 sleep-disordered breathing in association with disorders of respiratory muscles, chest wall or lung (e.g. muscular dystrophy, kyphoscoliosis, chronic obstructive pulmonary disease)
- 2.2.1.3 sleep-disordered breathing in association with recognized predisposing non-respiratory disorders (e.g. congestive cardiomyopathy, neurological disease, morbid obesity, acromegaly, hypothyroidism)
- 2.2.1.4 sleep-disordered breathing when upper airway surgery is being contemplated to treat snoring

2.2.1.1. Suspected Obstructive Sleep Apnoea

Patients in whom the question of OSA arises tend to fall into one of groups:

- a) Patients with a history of habitual loud snoring and marked daytime sleepiness and in whom apnoeas may also have been witnessed. There is a high probability of these patients have OSA and a sleep study is recommended.
- b) Patients in whom the history is less clear-cut. For example, snoring may be reported as positional and to have developed in association with weight gain and the patient may complain of mild daytime sleepiness. In these patients it is reasonable to defer sleep study pending response to measures to relieve nasal obstruction, reduce weight, or reduce alcohol consumption where these are thought to contribute. Exceptions, where sleep study should proceed, would include occupational drivers, patients with a history of an accident or "near miss" at work or when driving that could be related to sleepiness, or patients with coexisting vascular disease (e.g. ischaemic heart disease, cerebrovascular disease, or poorly controlled hypertension). Where sleep study has been deferred, formal follow-up is necessary with a plan to proceed with the study where symptomatic response to simple measures has been inadequate.
- c) Patients who present because of snoring but have no evidence of excessive daytime sleepiness or cardiorespiratory dysfunction. Occasional apnoeas may have been observed. The Committee considers that in an individual patient with this type of history the information obtained from sleep study is unlikely to be clinically useful and the test should therefore not be performed routinely, except where upper airway surgery is being contemplated (see below). Such patients should be advised of the importance of recognizing and reporting the occurrence of symptoms of sleep disruption, suggesting sleep apnoea may have supervened.

2.2.1.2 Sleep-disordered breathing in association with disorders of respiratory muscles, chest wall or lung (e.g. muscular dystrophy, kyphoscoliosis, COPD)

In patients with respiratory disorders in whom complications such as right heart failure, polycythaemia and hypercapnoeic respiratory failure appear disproportionately severe relative to the impairment of daytime respiratory function, the possibility of OSA or sleep hypoventilation should be considered, particularly if obese and/or known to snore habitually. A sleep study should be considered in the investigation of such patients.

Patients with respiratory and/or upper airway muscle weakness or chest wall deformity may develop sleep hypoventilation in advance of daytime respiratory or right heart failure (12;13). Hence sleep studies should be considered in this group if symptoms of disturbed sleep, nocturnal dyspnoea, snoring, morning headache, daytime sleepiness or progressive weakness are present(13). Studies should also be considered if signs of pulmonary hypertension or other cardiorespiratory dysfunction occur. Elevation of awake PaCO₂ in such patients may indicate a sleep-related respiratory disturbance.

A sleep study does not appear to be necessary solely for the purposes of establishing a patient with COPD on home O₂ treatment. This decision is usually made on the basis of wakeful PaO₂ (14). There is no evidence that isolated nocturnal desaturation causes progressive pulmonary hypertension (15;15) and one study has shown no significant treatment effect on survival or pulmonary haemodynamics from nocturnal oxygen therapy in such patients (16).

2.2.1.3 Sleep-disordered breathing in association with recognized predisposing non-respiratory disorders (e.g. congestive cardiomyopathy, cerebral neurological disease, morbid obesity, acromegaly, hypothyroidism).

A sleep study should be considered in patients with these disorders particularly if there is a history of excessive daytime sleepiness or deteriorating cardiorespiratory function not explicable on other grounds. In conditions where the prevalence of OSA is high, such as acromegaly (prevalence of more than 50% in unselected patients (17)), a sleep study should be a routine investigation.

Cheyne-Stokes breathing is often observed in association with congestive heart failure (in 30-50% of patients with an ejection fraction of <40%) or cerebral neurological disease (usually cerebrovascular)(18;19). Hypersomnolence can occur as a result of arousals seen during the hyperpnoeic phase of the breathing cycle. Significant hypoxemia may occur during the hypopnoeic phase. OSA is also common in patients with severe congestive heart failure (18;20) and may predispose to a decline in left ventricular function and quality of life (21).

2.2.1.4 Sleep apnoea where upper airway surgery is being considered to treat snoring

A sleep study should be undertaken whenever upper airway surgery is being contemplated to treat snoring. The reasons for this are that:

- a. the results may alert the surgeon and anaesthetist to the presence of clinically unsuspected sleep apnoea. This might indicate the need for alternative or additional treatments, or for particular vigilance in the early post-operative period because of increased potential for upper airway obstruction and/or impaired ability to arouse due to residual anaesthetic and/or analgesic effects.
- b. the cause of excessive sleepiness is investigated in patients in whom excessive daytime sleepiness is part of the rationale for surgery

2.2.2 INTERVENTION STUDIES

Intervention studies are performed to implement and titrate, or confirm the effectiveness of a new treatment. Such therapies include pharmaceutical agents, oxygen administration, dental devices to reposition the jaw, continuous positive airway pressure (CPAP), sleep posture modification devices and non-invasive ventilation (NIV). The effectiveness or otherwise of these treatments to reverse or alleviate sleep disordered breathing should be confirmed in individual patients by sleep study.

For OSA patients treated with CPAP it is necessary to establish: (i) that the airway pressure delivered maintains upper airway patency throughout sleep and (ii) that maintenance of airway patency has been associated with resolution of oxyhaemoglobin desaturation. Persistent serious arterial oxygen desaturation indicates the need to consider additional treatments. The standard method of CPAP titration and implementation is by attended polysomnography. There is, however, emerging evidence that, for some subgroups of patients with OSA, home treatment with auto-adjusting CPAP (22;23) or an empirical CPAP prescription (24) may produce patient outcomes similar to those achieved using in-laboratory polysomnography titrations. Indications for these more cost effective approaches will likely broaden as more information comes to light. Physicians managing OSA should be aware, however, that current evidence generally relates to highly selected patient sub-populations (eg patients who have few if any co-morbidities, are highly symptomatic with moderate –severe disease or require high therapeutic CPAP). It is recommended that CPAP implementation in complex cases (eg patients with overlapping cardiorespiratory dysfunction or central sleep apnea) be achieved by attended polysomnography.

2.2.3 FOLLOW-UP STUDIES

Where treatment for a sleep-related breathing disorder has been successfully instituted it is important to ensure its long-term efficacy. Objective assessments of long term treatment adherence (eg microprocessor-based CPAP compliance meters) and validated measures of effectiveness (eg Epworth Sleepiness Score, General or disease-specific QOL measurements) are highly desirable. Routine follow-up sleep studies are not necessary in patients who have experienced a reversal of symptoms and are stable. However, weight change or the recurrence of snoring or daytime sleepiness on fixed CPAP or mandibular advancement splint (MAS) may indicate the need for repeat diagnostic and/or therapeutic studies. Persistence of daytime sleepiness, despite correctly prescribed treatment may require additional studies to confirm satisfactory adherence, establish objectively the level of daytime sleepiness, and rule out alternative causes of daytime sleepiness. Follow-up sleep studies may also be required to assess disease progression in patients initially judged to have a mild abnormality but in whom symptoms have progressed.

2.3 TYPES OF RESPIRATORY SLEEP STUDY

Respiratory sleep studies may be divided into two broad *categories*:

- Polysomnography
- Limited channel sleep studies

In turn these studies may be *supervised* as follows:

- Attended
- Unattended

Their *duration* may be:

- Full night
- Split-night
- Restricted duration

Definitions

Polysomnography (PSG) or "comprehensive" study requires the continuous recording of multiple physiological variables to measure sleep architecture and cardio-respiratory function during sleep. 12-13 recording channels are routinely recorded that include: 2 electroencephalogram (EEG) signals, bilateral electro-oculograms (EOGs), submental electromyography (EMG), electrocardiography (ECG), bilateral anterior tibial muscle activity or leg movements, arterial O₂ saturation, respiratory thoraco-abdominal movements and (nasal pressure and oronasal thermocouples airflow). Other variables may be additionally recorded such as digital video, transcutaneous CO₂, sound and oesophageal pressure (respiratory effort). A Type 1 study refers to a laboratory based PSG. A Type 2 study or monitor refers to a portable PSG device.

Limited channel sleep study: a more restricted number of variables are measured, usually a combination of respiratory variables including arterial O₂

saturation, respiratory effort and airflow. In general sleep staging is omitted from limited sleep studies. A Type 3 study is one that incorporates at least 4 monitored channels and a Type 4 only one or two measured parameters (see below).

TABLE 1.

STUDY TYPE	DESCRIPTION
Type 1	Polysomnography (PSG) is considered the reference standard against which other monitors are evaluated. Recordings are made in a sleep laboratory with trained sleep laboratory staff in attendance. 12-13 recording channels are routinely recorded 2 EEG, 2 EOGs, submental EMG, ECG, bilateral leg movements, arterial O2 saturation, respiratory thoraco-abdominal movements and airflow (nasal pressure and oronasal thermocouples).
Type 2	Minimum of seven channels, including EEG, electrooculogram (EOG), chin EMG, electrocardiogram (ECG) or heart rate, airflow, respiratory effort, oxygen saturation. This type of monitor allows for sleep staging and therefore calculation of an AHI. It is configured in a fashion that allows studies to be performed in the home.
Type 3	Minimum of four channels monitored, including ventilation or airflow (at least two channels of respiratory movement, or respiratory movement and airflow), heart rate or ECG and oxygen saturation
Type 4	Monitors of this type measure a single parameter or two parameters – for example oxygen saturation or airflow.

Attended: a study continuously attended by medical, scientific/technical or nursing staff specifically trained in the performance of sleep studies.

Unattended: a study where staff with such training are absent during the recording period. These studies are usually undertaken using portable equipment and are located in the home.

Full night: a study conducted over the entire normal sleep period, beginning at the usual bedtime and usually lasting more than 6 hours.

Split-night study: an overnight sleep study “split” into two parts. It has a diagnostic period followed by a therapeutic intervention (most commonly, identification of moderate or severe OSA followed by CPAP titration).

Limited duration: a study where the planned length of study is less than 6 hours. Such studies would include "nap" studies conducted during daylight hours.

2.4 CHOOSING THE TYPE OF RESPIRATORY SLEEP STUDY

In choosing which test or tests are to be used, physicians should have a clear understanding of: (a) the indications for testing; (b) the sensitivity and specificity of the test(s) to diagnose sleep disordered breathing, (c) the overall utility of the test taking into consideration the prevalence of sleep apnea in their population; and (d) the cost /benefit balance of the test in their particular clinical setting. They should also be thoroughly conversant with the technical aspects of the chosen test(s).

2.4.1 POLYSOMNOGRAPHY (PSG)

2.4.1.1 *Attended*

There is ongoing debate regarding the existence of a “gold standard” against which the different types of studies should be compared. Attended PSG has traditionally been accepted as the “gold standard” but without rigorous evaluation of its accuracy and reliability. If readily available, attended PSG is the optimum sleep study for most patients requiring sleep investigation.

PSG allows measurement of sleep stage and accurate quantification of respiratory events (against time spent asleep). REM sleep is frequently associated with exacerbation of the sleep related breathing abnormality and, in some cases sleep apnoea/hypopnoea may be confined entirely to REM sleep. It distinguishes obstructive from central events, determines the effects of sleep position on sleep disordered breathing, allows the recognition of some alternative diagnosis (eg. periodic limb movement disorder) and may suggest others (eg narcolepsy, chronic sleep restriction due to circadian rhythm disturbance). It provides information on sleep fragmentation and arousals which are likely important in the genesis of daytime symptoms arising from abnormal sleep-related respiratory events.

2.4.1.2 *Unattended*

A recent systematic review of home sleep studies for the diagnosis of OSA concluded that there was insufficient evidence to recommend the use of home PSG (3). This review only considered research studies that directly compared such devices with attended PSG. The potential role of a full PSG set-up by a technician in the home may have been underestimated by this approach. Full home PSG was used by the Sleep Heart Health Research Group who performed over 7000 studies to a high technical standard(25) with reasonable agreement with repeated studies at home(26) and in the laboratory (27). Home set-up PSG, is thus technically feasible and may provide reliable data. Its application in a general clinical sleep apnea population has, however, yet to be reported and specific occupational, health and safety issues are raised

for technical staff so involved. Whether or not it is more cost-effective is unknown.

2.4.2 LIMITED CHANNEL SLEEP STUDIES

The high demand for sleep study investigations plus the relatively costly and labour intensive nature of overnight attended PSG has led to the development of numerous, simpler sleep study devices that are potentially suitable for home diagnosis. In general these are limited channel recording devices that do not include electrophysiological measurements of sleep and in which the respiratory channel recordings have been reduced in number or simplified. Many also provide some form of automated analysis. A major systematic review was recently undertaken of portable monitoring in the investigation of suspected sleep apnoea in adults (3). This was followed by a companion executive summary (28) and revised practice guidelines(29). These reports highlighted a number of deficiencies in current research into the utility of portable monitoring devices. These included

- A paucity of high quality information on the performance and accuracy of these devices when used in the home (ie their intended application)
- Lack of standardisation between measurement devices

Most studies compared the diagnostic accuracy of the portable device with PSG (the diagnostic “gold standard”) during simultaneous in-laboratory recordings. Two-thirds of these studies were considered to have met a high standard of evidence and quality. In only 25% of studies were home (unattended) portable device measurements compared with attended PSG and less than one-third of these studies met a high standard of evidence and quality. The report acknowledged that night-to-night variability in SDB makes it difficult to compare home monitor and attended PSG results, but it also suggested a study design to account for this variability in future investigations.

In all studies the diagnostic accuracy of the portable devices was assessed using the Bayesian theorem. OSA was defined by a PSG apnea-hypopnea index (AHI) cut off that was considered by investigators to be clinically important (typically AHI 15). The report acknowledged that AHI alone does not define the syndrome of sleep apnea and that the use of a single PSG-defined AHI cut off to define “disease” and thereby the utility of new diagnostic method may be less than ideal. Thus, achieving a high degree of precision in terms of sensitivity and specificity around a particular AHI cut-off may be less important than how the use of a portable diagnostic device (compared to traditional attended PSG) affects clinical decision making and patient outcomes. To date there have been virtually no proper randomised controlled studies comparing decision making and/or patient outcomes with portable diagnostic devices versus attended PSG. Meanwhile it should also be acknowledged that PSG-defined AHI has been the metric used for defining OSA severity in almost all cross sectional and longitudinal studies that have shown relationships between sleep apnea and important neurobehavioural and cardiovascular

outcomes. Thus, a continued search for a portable device that accurately, reliably and cost-effectively measures the frequency of apneas and hypopneas in the home remains an important endeavour.

2.4.2.1 Attended (in-hospital or in-laboratory) diagnostic studies

The review (29) concluded that current evidence supports the use of some Type 3 portable devices (multiple respiratory channels without sleep electrophysiology recordings) for both “ruling in” and “ruling out” the diagnosis of OSA in the attended setting. Thus, in situations where resources are limited some savings may accrue from in-hospital supervised Type 3 sleep studies without significantly compromising accuracy.

Hospitalised patients suspected of having sleep disordered breathing who are too sick to be transferred to the sleep laboratory may also benefit from attended limited channel sleep studies. Information may be used to help direct and monitor acute management (eg bilevel pressure support ventilation). However, the utility of limited sleep studies in diagnosing OSA in such populations has not been systematically studied, and false positive results are likely to be increased if baseline hypoxemia, secondary to acute cardiorespiratory dysfunction, is present.

2.4.2.2 Unattended (ie home) diagnostic studies.

The above review concluded that there is insufficient evidence currently to recommend the routine use of portable devices to diagnose (ie both “rule in” and “rule out”) OSA in the home setting. Thus, until adequate studies of the sensitivity and specificity of limited channel home sleep studies are available, their limits, usefulness and appropriateness remain largely undefined.

2.4.2.3 Unattended (ie home study) to help “rule in” moderate - severe OSA

Patients with severe OSA may be at risk of accidents or adverse cardiovascular events while awaiting investigation if access to PSG is limited and waiting lists are long. While the evidence is limited, the recent review of home monitoring (3) suggests that home testing with single or dual channel monitors (ie Type 4 monitors) may be able to positively identify (ie “rule in”) a fairly high percentage of such patients within sleep clinic populations with a reasonable degree of accuracy. The most common monitor investigated was overnight pulse oximetry. With some modern oximeters, high sampling rates, decreased averaging times, and improved analysis algorithms increase test sensitivity and specificity such that the likelihood ratio for a positive test result can be high enough to help "rule in" sleep apnea (3;30). The same may pertain to some multichannel respiratory recorders (Type 3 devices) although the evidence is currently much less convincing. Thus, in clinic populations where there are long waiting lists and a high pre-test probability of OSA (eg 40-60%), it may be expeditious to identify patients with moderate-severe disease by home testing with a limited channel device. This information could then be used to help prioritise the waiting list for PSG and clinical review or

allow treatment to be fast tracked in some patients. Such an approach might also be useful in remote areas to allow recognition of advanced cases of sleep apnoea that might then be referred for comprehensive work-up and treatment. The higher the AHI cut-point used to identifying cases the less will be the concern that “false positive” cases will receive inappropriate treatment or a false diagnosis of OSA. There is insufficient evidence to recommend that limited channel devices be used to "rule out" sleep apnea in an unattended setting, and therefore symptomatic patients with a “negative” result should proceed to PSG.

2.4.2.4 Studies to assess the effectiveness of therapy in patients who remain symptomatic

Patients should first be re-evaluated clinically to determine the need for and type of repeat sleep testing. An attended PSG to ascertain the adequacy of treatment in all stages of sleep and sleep postures and to rule out other disorders such as periodic limb movements of sleep is generally preferred, but other tests such as MSLT may also be indicated. A limited channel study may be useful to check the adequacy of treatment if the initial diagnosis was made by full PSG.

2.4.2.5 Concluding remarks and recommendations.

It is important to note that almost all research studies reporting the diagnostic utility of portable or limited channel sleep study devices have been conducted in sleep apnea clinic populations where pre-test probability of OSA is relatively high (eg 40-60%) and amongst patients without significant co-morbidities (eg COPD). The diagnostic utility of these devices may change substantially if pre-test probability of disease is significantly lower (eg employment or GP screening) or if patients with cardio respiratory co-morbidities are included. Also, many different portable monitors are available and it is not possible to generalize results from one monitor across all monitors of even of a particular type.

It is recommended, therefore, that if portable, limited channel sleep studies are to be used this should only be under the supervision of an accredited sleep physician who is familiar with the strengths and weaknesses of these types of studies and who is knowledgeable about the specific device to be used.

The following should apply

- Studies should be conducted only in the context of expert assessment of the patient's sleep problem.
- Raw data should always be available from the limited channel device for review.
- The physician should have access to facilities for comprehensive PSG if required

- Clinicians working in remote areas should establish formal links with a centre that has such expertise and facilities before considering undertaking limited channel studies.

It must be recognised that where the study is limited channel and/or unattended it may require to be repeated more frequently than attended PSG because of the limitations imposed by lack of sleep staging or unrecognised technical malfunction overnight. Studies at home on successive nights are useful as this allows the internal consistency of the data to be examined. In view of these limitations, together with set-up/training time, and time for analysis, the cost effectiveness of partial studies requires ongoing scrutiny.

Limited channel (home) studies are inappropriate

- If the patient is uncooperative (eg some psychiatric disorders) or has poor comprehension
- Where the possibility of more than one sleep disorder is under investigation
- If the study is conducted for Medico-legal purposes
- If the patient has serious co-morbidities e.g. cardiac or respiratory disease

2.4.3 SPLIT POLYSOMNOGRAPHY STUDIES

As an investigation strategy split night studies can increase sleep study efficiency, expedite treatment, and lead to potential cost savings (31;32). Patients referred for split-night sleep studies (initial diagnostic PSG followed on the same night by CPAP titration) should be assessed as having a moderate to high probability of having OSA. Split night studies can determine effective CPAP pressures if severe OSA (AHI>40/h) is identified during a minimum of 2 hours diagnostic testing and at least 3 hours of sleep is present subsequently for CPAP titration during which obstructive events are eliminated, including during supine REM sleep (6;31;32). Under these circumstances it is usually possible to identify an acceptable mask interface and management strategy. It is recommended that the attending sleep scientist determines the adequacy of the diagnostic period based on pre-established criteria (eg as above) allowing the study to be converted to CPAP titration or continued for a full night of diagnosis.

2.5 PREPARATION AND INSTRUCTIONS TO PATIENTS BEFORE STUDY

The condition of the patient at the time of the study will in large part, determine the result obtained. Studies performed while the patient is acutely unwell, such as early during an inpatient admission, are unlikely to provide meaningful information about the underlying sleep disorder. For example, studies performed while the patient is in respiratory failure may provide information for acute management but should not be used as a basis to establish the patient on long term treatment.

The use of alcohol, sedatives and hypnotics immediately prior to the study will exaggerate an underlying problem with obstructive sleep apnoea. Similarly, patients with COPD are likely to demonstrate more sleep hypoxaemia during an acute exacerbation of their disease. It is the responsibility of the clinician ordering the test to decide whether it should be performed following the withdrawal of aggravating drugs or after appropriate treatment of underlying disease. The decision is likely to hinge on the particular question to be answered. In some instances studies under both circumstances may be desirable. At the very least the physician reporting the test should be fully aware of the condition of the patient at the time of sleep study and interpret the result accordingly.

Patients should be instructed to follow normal activities of daily living prior to presentation for the study. Unless the study is being performed for a special purpose, patients should maintain their regular sleep habits prior to the study.

2.6 MEASUREMENT TECHNIQUES

2.6.1 POLYSOMNOGRAPHY (8)

2.6.1.1 General

Respiratory sleep studies should employ, whenever possible, non-invasive methods for evaluating sleep and respiratory and cardiac function. A complete and permanent record of the study should be made and a written report issued (*see following sections on "Recording and Analysis" and "Laboratory Report"*).

The following measurements are made in a comprehensive clinical respiratory sleep study:

2.6.1.2 Sleep Staging

Assessment of the amount and structure of sleep is important for a thorough understanding of a respiratory sleep disorder. A study containing less than three hours total sleep or in which a REM sleep period is not recorded may underestimate the severity of sleep disordered breathing and comment on this limitation should be made by the reporting clinician. The proper evaluation of sleep requires the continuous surface measurements of electroencephalogram (EEG; preferably at least two channels), electro-oculogram (EOG; bilateral to enable conjugate eye movements to be detected) and submental electromyogram (EMG; to assess muscle tone). Detailed descriptions are given elsewhere on technical aspects of the preferred types of electrodes and their placement.

2.6.1.3 Detection of Airflow

Reliable measurement of respiratory disturbance requires the use of quantitative or semi-quantitative transducers. The gold standard of a pneumotachograph is not practical for routine use. Pressure recording from nasal cannula is the simplest semi-quantitative technique and is accepted as the primary standard (8). It may however give a false impression of the reduction in airflow when mouth breathing is significant. Use of respiratory inductive plethysmography (RIP) provides a useful adjunct where independent measures of thoracic and abdominal movement or, preferably, a calibrated sum signal provides additional information. Qualitative transducers such as nasal and oral thermistors and expired CO₂ monitors do not allow accurate determination of the reduction in airflow and should be used only where additional information, such as from nasal pressure or RIP, is available.

2.6.1.4 Measurement of pressure during CPAP or NIV studies

Measurement of changes in mask pressure in studies where the patient is being treated with positive pressure ventilation provides a semi-quantitative measurement of airflow. Pressure fluctuations occur with inspired and expired flow. The measurement of pressure at the flow generator is considered inferior to pressure measurement at the mask/patient interface which documents the pressure actually delivered to the patient at the mask. Variations in pressure at the mask can also be used to demonstrate leak. The use of additional signals derived from the flow generator has not been shown to add significant additional information. The use of semi-quantitative respiratory inductive plethysmography (RIP) provides a useful adjunct to pressure measurement at the mask.

Measurement of absolute mask pressure is also necessary during CPAP or NIV studies to either:

- a) allow the correct therapeutic level of pressure to be titrated (intervention studies); or
- b) to ensure that the prescribed level of pressure is being delivered (follow-up studies).

2.6.1.5 Respiratory Effort

Together with the information on airflow, a measure of respiratory effort is needed to define the presence and type of sleep apnoea. The reference standard is oesophageal manometry which detects and can quantify changes in pleural pressure. However, for routine respiratory sleep studies a semi-quantitative assessment of respiratory effort is sufficient. This can be achieved by placing transducers on the chest and abdominal walls to detect respiratory movement. The preferred method is respiratory inductive plethysmography (RIP) where independent measures of thoracic and abdominal movement are obtained. Piezo sensors, strain gauges and impedance measurement may be used but are subject to significant variation when the patient changes sleep position and may give misleading information. Paradoxical motion of the thorax and abdomen is a useful indication of upper airways flow limitation and is only reliably measured using RIP. An alternate method of measurement sometimes used is the recording of respiratory

muscle EMG by chest wall surface electrodes. In the great majority of cases measurements of chest wall motion are adequate to distinguish between central and obstructive apnoeas and the alternate measurements of respiratory EMG or oesophageal manometry should be considered an adjunct where more detailed information is sought.

2.6.1.6 Arterial Oxygen and Carbon Dioxide

Measurement of arterial oxygen saturation is critically important in determining the impact of the disordered breathing and should form part of all respiratory sleep studies. Many pulse oximeters are commercially available for continuous non-invasive measurement of oxygen saturation (SpO₂). These oximeters differ in the processing of the signal and in response times. Averaging time in excess of 3 secs can significantly underestimate desaturation in sleep (33). Laboratory staff should critically appraise pulse oximeters for their ability to reliably detect moderately rapid changes in SpO₂ as experienced during an apneic event. Above an SpO₂ of approximately 70% pulse oximeters appear accurate to within 2%. At lower SpO₂ levels the accuracy of these devices decreases, causing SpO₂ to be either over or underestimated(34;35). Some investigators have also reported important discrepancies between SpO₂ values obtained simultaneously at different sampling sites (eg finger and ear lobe)(35). Notwithstanding these shortcomings, most devices provide sufficiently accurate information to assess the effects of sleep disordered breathing on ventilation and pulmonary gas exchange and SpO₂ measurements are considered a mandatory component of the respiratory sleep study. The method is unaffected by skin pigmentation, however poor peripheral perfusion or abnormal forms of haemoglobin may interfere with the accuracy of the measurement. Newer pulse oximeters with motion resistance algorithms have theoretical appeal (36) but they have not been systematically evaluated in the context of sleep studies.

Arterial CO₂ and O₂ partial pressures can be estimated using trans-cutaneous electrodes. The skin is heated under an enclosed surface and the partial pressures of CO₂ and O₂ diffusing through the skin are measured using standard polarographic electrodes. The method is best suited to neonates where the correlation between transcutaneous and arterial partial pressures is good except where peripheral circulation is compromised. These devices require frequent, careful calibration and are best suited to following trends rather than measuring absolute values. Instrument response times are slow and they are only useful for measuring slowly changing arterial PCO₂ values.

Because of these limitations, there is no established role for transcutaneous O₂ electrodes in routine respiratory sleep studies. However transcutaneous CO₂ electrodes are useful in assessing disorders in which prolonged sleep-related alveolar hypoventilation is present or suspected (eg neuromuscular disease). Transcutaneous CO₂ electrodes are also useful in confirming the adequacy of nocturnal mechanical ventilatory assistance in such patients. They are less useful in assessing changes associated with the relatively rapid variations in ventilation of OSA, but may help quantify severity where

prolonged periods of hypoventilation coexist (eg during REM sleep in the morbidly obese).

Arterial PCO₂ levels may also be estimated non-invasively by end-tidal CO₂ measurements, sampling from a nasal cannula, although the accuracy of this estimate is diminished in the presence of unevenly distributed ventilation and upper airway obstruction.

2.6.1.7 Electrocardiogram

The electrocardiogram should be recorded continuously. The purpose is to determine whether there are significant disturbances of cardiac rate and/or rhythm associated with disordered breathing events. A single lead ECG which clearly describes the P wave and QRS complex is adequate for these purposes. Devices that record instantaneous or average heart rate or the R-R interval may be used in addition but not in place of the ECG. All types of sleep study recording systems should have the capacity to more closely examine the ECG record when a disturbance is suspected, for example by playing back the appropriate portions of a Holter Monitor recording, or by displaying at high resolution the relevant section of ECG data stored on computer.

2.6.1.8 Limb movement

Limb movements, typically legs, are present in the disorder of Periodic Limb Movements of Sleep and may also be present in Restless Legs Syndrome. These are common differential diagnoses of sleep apnoea in investigation of the patient with a history of sleep disruption and/or excessive daytime somnolence, particularly amongst the elderly. Limb movements may be measured by anterior tibialis muscle activity detected by surface EMG. Other transducers such as strain gauge or motion sensor designed to detect movement of the limb are also satisfactory.

2.6.1.9 Sleep Position

Sleep position is an important variable influencing the occurrence and severity of sleep apnoea and its assessment by direct visual recording or gravity influenced switch should be undertaken as a routine. Where a patient fails to sleep in the supine position in the first half of the study, consideration should be given to encouraging this sleep position as it is likely to exacerbate any respiratory abnormality.

2.6.1.10 Sound recording

Snoring occurs in response to upper airway narrowing and flow limitation. Sound recording is useful in detecting snoring and providing confirmatory evidence of flow limitation. Sound may be recorded from a microphone but calibrated sound level meters are preferred because they allow semi-quantitative measurement of sound intensity. Comparison of sound intensity before and after intervention may be critical in assessing the success of the surgical or other procedures.

2.6.1.11 Video recording

Video recording is not generally indicated for respiratory sleep studies but is important if a differential diagnosis of parasomnia is being considered. Video recording must be conducted under extremely low light conditions and is best accomplished with cameras sensitive to low light and is often augmented with a low intensity infra-red light source in the room. Where video recording is indicated, It should be time locked to the polysomnographic recording.

2.6.1.12 Light

The light on/off status of the study should be recorded with the polysomnogram data. This is important for the measurement of latency to sleep.

2.6.2 LIMITED CHANNEL STUDIES

The reader is directed to a recent systematic review (3) for guidance on those specific devices that have been demonstrated to have diagnostic utility and those that have not. This review and the source references provide information on the respiratory parameters measured in each device. A companion paper (30) provides guidance on how to assess the quality of studies on limited channel devices. In principle, statements concerning transducers and instrumentation made above under PSG (2.6.1) also apply to limited channel devices.

2.6.3 OTHER MEASUREMENTS

Other measurements may be incorporated in the sleep study to investigate specific disorders, such as oesophageal pH monitoring for gastro – oesophageal reflux). These should be considered as adjuncts to those outlined above.

Other protocols may be required for patients presenting to sleep clinics that use variables referred to in this section. Examples are the Multiple Sleep Latency Test and Maintenance of Wakefulness Test which are used to objectively assess the degree of daytime sleepiness (*see Section 4 below*).

2.6.4 CALIBRATION OF MEASUREMENTS

Calibration of all signals in which the absolute value is important should occur regularly. Examples include SpO₂, TcCO₂, CPAP pressure, sound level, position and EEG. The frequency of calibration depends on the stability of the transducer and the likelihood that an intrinsic or extrinsic factor could cause an error in the value reported. If the signal is critical to the interpretation of the study, for example SpO₂ or CPAP pressure, it should be calibrated prior to each study. If loss of the signal would still allow interpretation and the transducer is stable, weekly calibration is acceptable. Accurate determination of sleep stage requires measurement of the amplitude of the EEG signals and

hence the EEG channels should also be calibrated. In most systems the gain of the EEG channels is stable over a long period of time and monthly calibration of these channels is adequate.

In addition to calibration of the gain of channels the frequency response should be checked on a regular basis. If the frequency response of a channel used for EEG, EOG or EMG is reduced the recorded waveform will be inaccurate. The response of channels in which frequency is important to interpretation should be checked monthly.

2.6.5 CHECKING MEASUREMENTS (BIOLOGICAL CALIBRATION)

Prior to each study all signals being recorded should be checked for satisfactory operation. The results of this check should be recorded with the study so that the reporter can have confidence that the signal was being recorded. One laboratory staff member should instruct and observe the patient in the performance of the appropriate manoeuvre while another staff member checks the polysomnogram signal. The nature of the manoeuvre should be recorded on the polysomnogram recording at the time it is performed.

2.7 RECORDING AND ANALYSIS

2.7.1 DATA STORAGE

Data obtained during the sleep study should be stored in digital form (computer disc or similar storage device) for subsequent analysis. The record should be complete (allowing full disclosure of the raw data) and a permanent copy retained. Careful storage of the record is recommended so that the data may be retrieved for comparison with subsequent recordings or reanalysis. This may be required for clinical, educational, research or medico-legal purposes.

2.7.2 SLEEP STUDY SCORING: VISUAL VERSUS AUTOMATED; QUALITY CONTROL

In recent years computer based systems have largely replaced the traditional method of continuous recording on a multi-channel paper chart recorder with subsequent visual analysis. While these computerized systems offer a satisfactory method of recording information, the accuracy of software analysis packages provided for automated sleep staging and the detection and characterization of disordered breathing events in general remains undefined. One recent study of an automated scoring system in a sleep apnea population reported that for sleep and respiratory events the level of agreement between automatic and manual scoring was similar to that between trained manual scorers(37), but these findings await confirmation by other laboratories. The difficulties of automatic scoring relate primarily to defining the stages of sleep and wakefulness, for which the definitions of Rechtschaffen and Kales(38) remain the standard. The main difficulty with computerized systems is in adequately programming the computer to

recognize, with the same accuracy as the trained observer, the inter-subject variability in EEG waveforms that exist independently of variations in the state of sleep or wakefulness. Thus, at this time the committee considers that fully automated sleep and respiratory event scoring is not an acceptable alternative to careful scrutiny and staging of the raw data by appropriately trained personnel. However by presenting the data in provisionally analyzed and summarized forms these systems offer significant aids to analysis and allow a reduction in time taken for sleep staging. For similar reasons it is necessary to score arousals visually, using relevant criteria (39). Automated respiratory event analysis is better than for automatic sleep scoring, but again difficulties can arise because of inter-subject variability in signal quality or changes over a single night in signal amplitude or quality in an individual. Considerable error can arise in calculation of respiratory disturbance indices and the characterization of events (e.g. obstructive or central) unless the threshold and diagnostic criteria for computer analysis are frequently reviewed. Consequently the computer scoring must be reviewed visually against the raw data and rescored manually.

Each laboratory should aspire to meet international benchmarks for accuracy and inter- and intra- scorer reliability for the scoring of parameters such as respiratory events, sleep stages, leg movements and arousals. This can be achieved in each laboratory by using internationally agreed scoring definitions (8) and by using a set of sleep studies that have been scored as standard to which other staff can measure their ability to score the various parameters. As a guide agreement of 80% or greater should be achieved for most sleep and respiratory parameters (40). The exception to this is arousal from sleep which may achieve a concordance of only 55% to 60% (40). Programs designed to monitor between laboratory scoring differences and encourage their reduction are strongly endorsed.

2.7.3 DEFINITIONS OF SLEEP-RELATED RESPIRATORY EVENTS

Standardised criteria are essential for scoring sleep-related respiratory events (AASM-Chicago criteria) (8)

Apnoea

An apnoea is defined as cessation of breathing for 10 seconds or longer. Three types are recognized:

- a) Obstructive: apnoea associated with evidence of persisting respiratory effort
- b) Central: apnoea associated with cessation of breathing effort
- c) Mixed: mixture of central and obstructive features

Hypopnoea

A hypopnoea is defined by the presence of the first or second of the following criteria, plus the third (1 or 2, plus 3):

1. A clear decrease (>50%) from baseline in the amplitude of a valid measure of breathing during sleep (quantitative or semi quantitative flow

(e.g. pneumotachography, nasal pressure or thoraco-abdominal motion (e.g. summed rib cage plus abdominal respiratory inductance plethysmography) - see reference 7 for details). Baseline is defined as the mean amplitude of stable breathing and oxygenation in the two minutes preceding onset of the event (in individuals with a stable breathing pattern during sleep) or the mean amplitude of the three largest breaths in the two preceding minutes where breathing pattern is unstable.

2. A clear amplitude reduction of a valid measure of breathing during sleep that does not reach the above criterion but is associated with either an oxygen desaturation of >3% or an arousal.
3. The event lasts 10 seconds or longer.

Distinguishing obstructive from central hypopnoeas

These may be distinguished by observation of a concordant reduction in respiratory effort and flow in the case of central hypopnoeas. However, this separation is problematic even with the aid of oesophageal pressure measurement as there is no relative or absolute reduction in oesophageal pressure which can be used to distinguish them. Precise measurement of reduction on oesophageal pressure and flow are both required to detect changes in airway resistance associated with obstructive events and this is not possible with currently available clinical devices. The presence of paradoxical rib cage motion can be useful in helping distinguishing obstructive hypopnoeas (where it is often present) from central hypopnoeas (where it is not).

Respiratory effort-related arousal (RERA)

A RERA is defined as an arousal from sleep that follows a 10 second or longer sequence of breaths that are characterized by increasing respiratory effort, but which does not meet criteria for an apnoea or hypopnoea. Snoring, though usually associated with this condition need not be present (41). Respiratory effort is measured via oesophageal pressure monitoring. Where oesophageal pressure is being monitored the pattern is one of progressively more negative pressure terminated by a sudden change to a less negative level and an arousal(8). A useful surrogate for oesophageal pressure monitoring is the use of nasal pressure signal with progressive inspiratory flattening followed by an arousal (42;43).

RERA's have the same implications for sleep fragmentation and consequent daytime sleepiness as do apnoeas and hypopnoeas. Some patients who have symptoms suggestive of OSA have few apnoeas or hypopnoeas on polysomnography, but frequent respiratory effort related arousals to which their clinical presentation can be related. This condition has been termed Upper Airway Resistance Syndrome (44), although the basis of its separate status from OSA syndrome appears related to sensitivity of the respiratory measurements, as they have a shared clinical and pathophysiological basis (45).

Similarly, the distinction between obstructive apnoeas and hyponoeas is not particularly important clinically as both types of events have similar pathophysiology and consequences. They both usually produce desaturation and end in arousal. There are no current data to suggest different long or short term outcomes in patients with predominantly apnoeas as compared to hypopnoeas (8).

2.7.4 SEVERITY CRITERIA FOR OSA (8)

2.7.4.1 *The apnoea – hypopnoea index (AHI)*

The AHI has been used in clinical trials and epidemiological studies to classify patients as either having OSA or being normal, as well as to classify the severity of OSA.

The Chicago criteria (8) recommend the following classification of OSA severity

Normal:	AHI <5 events per hour of sleep
Mild OSA:	AHI 5 to 15 events per hour of sleep
Moderate OSA:	AHI 15 to 30 events per hour of sleep
Severe OSA:	AHI > 30 events per hour of sleep

The use of an event frequency of 5 per hour as a minimum value to diagnose OSA was based on epidemiological data that suggest it may be associated with measurable health effects such as sleepiness, motor vehicle accidents and hypertension(46;47). The latter risk appears substantial at 30 events per sleep hour. In addition intervention studies suggest treatment of subjects with between 5 and 15 events per sleep hour relieves sleepiness and may improve neurocognitive function (46-50).

This AHI grading needs to be used with caution in describing severity of sleep disordered breathing in present day laboratories. The research studies underpinning the Chicago recommendations on OSA severity used oronasal thermistors to score respiratory events and in general, the most definitions of hypopnea incorporated arterial oxygen desaturation. However, most clinical laboratories now use nasal pressure, a more sensitive index of airflow, to detect sleep disordered breathing events and many also have adopted the Chicago definition of hypopnea (see 2.7.3), which does not mandate a fall in arterial oxygen saturation. Thus, studies will now generally be scored with higher AHI values. Clinicians using the above criteria should adjust the AHI cut-offs based on the best available evidence (preferably data obtained in their own laboratory comparing previous and present day recording and scoring methods).

2.7.4.2 *Daytime Sleepiness*

The Chicago consensus standards(8) for severity of daytime sleepiness are as follows:

Mild: Unwanted sleepiness or involuntary sleep episodes occurring during activities requiring little attention (e.g. watching television, reading, travelling as a passenger). Symptoms produce minor impairment of social or work function.

Moderate: Unwanted sleepiness or involuntary sleep episodes occurring during activities requiring some attention (e.g. attending concerts, meetings, presentations). Symptoms produce moderate impairment of social or work function.

Severe: Unwanted sleepiness or involuntary sleep episodes occurring during activities requiring more active attention (e.g. while eating, conversing, or driving). Symptoms produce marked impairment of social or work function.

2.7.4.3 Sleep Hypoxemia

An oxygen saturation of <85% for more than 50% of sleep time (breathing air) has been suggested (8) as another threshold value defining severe sleep-related hypoventilation.

2.7.4.4 Further considerations

The above are useful guidelines for grading the severity of sleep disordered breathing and its cardinal manifestation, daytime sleepiness. However, the clinician, in assessing the likely importance of disease and potential benefits of treatment in an individual patient, must be alert to specific aspects of the patient's sleep study and other pertinent clinical findings. An assessment of the severity of sleep disordered breathing in clinical practice should include:

- i) *Careful evaluation of the PSG pattern of sleep disordered breathing.* In general the higher the AHI the more severe the sleep apnoea, but significant or even severe sleep-disordered breathing may be present with low AHI values. For example, RERAs (see 2.7.3) are not included in the AHI, yet may be contributing to adverse clinical outcomes. Sleep disordered breathing events may be confined to the supine position and/or REM sleep. If supine sleep and/ or REM sleep are under represented on the study night the computed AHI will underestimate the severity of the underlying OSA. If obstructive events are unusually long desaturation may be severe but AHI low. The level of oxygen desaturation is worthy of independent consideration particularly in the context of co-existing cardiovascular disease. Thus, the reporting physician should carefully review sleep study findings including raw data, and a qualitative interpretation should be provided along with AHI and other data.
- ii) *The patient's clinical circumstances.* Marked daytime sleepiness with a low AHI may indicate that the severity of sleep disordered breathing has been underestimated by the sleep study, but equally, alternate or additional causes for the sleepiness may be present, such as chronic sleep restriction, sedating drugs or periodic limb movements of sleep.

The impact of the sleepiness should also be considered. For example, sleepiness in a long distance bus or truck driver will be of particular importance. There is emerging literature which suggests that OSA may be an independent risk factor for cardiovascular disease. Thus, the presence of co-existing cardiovascular risk factors or disease in a patient may influence the clinician to advise treatment at a lower AHI severity cut off than would normally be the case (51).

2.8 LABORATORY REPORT

A written report should be issued at the completion of all sleep studies detailing:

- a) the variables measured.
- b) sleep staging (if performed), including total sleep time, sleep efficiency, sleep latency, percentage of time in the various sleep stages, and frequency of arousals.
- c) frequency and type of abnormal respiratory events (e.g. central or obstructive).
- d) relationships of disordered breathing to posture (if measured), sleep stage or treatment intervention when relevant.
- e) oxygen saturation, described in quantitative terms using either a continuous saturation versus time plot or by using discrete intervals (e.g. sleep time spent within various ranges of saturation). The lowest saturation recorded during abnormal respiratory events should be noted.
- f) transcutaneous PCO₂ trends, where measured.
- g) any disturbance of cardiac rate or rhythm, and its relationship to abnormal respiratory events, if measured.
- h) the frequency of periodic limb movements and any associated sleep fragmentation.
- i) medications (including sedatives) and alcohol that may have influenced the results.
- j) technician's comments.
- k) physician's interpretation/conclusions.

3. MOVEMENT AND BEHAVIOURAL DISORDERS OF SLEEP(6)

3.1 INDICATIONS FOR SLEEP STUDY

The most common movement and behavioural disorders of sleep in adults are restless legs syndrome (RLS)/ periodic movements of sleep (PLMS), REM behaviour disorder, and NREM parasomnias such as sleep walking/ sleep talking or night terrors. Complex partial seizures may be confined to sleep and patients with these disorders will also occasionally present to a sleep disorders service. Most of these disorders can be diagnosed by careful history taking and do not routinely require polysomnography. For example,

RLS can usually be diagnosed by eliciting the typical history of lower leg dysaesthesiae that are worse in the latter part of the day or evening, and are relieved temporarily by movement. Similarly, REM behaviour disorder and NREM parasomnias can usually be readily distinguished one from the other. The former usually affects an older patient group, and in contrast to NREM movements or vocalisations, is closely coupled to dreaming from which the subject is easily awoken. Seizure disorders which typically produce stereotypic movements during sleep can often be identified from history, neurological examination and awake EEG. However, some cases of abnormal movement and behaviour during sleep may require polysomnography to assist in diagnosis and to direct management. This will be particularly so where there is a history of sleep-related violence, the history is ambiguous (excessive movements during sleep but no RLS) or where overlapping disorders are suspected (eg RLS/PLMS and OSA).

3.2 TYPES OF SLEEP STUDY

Polysomnography should be used and in the case of reports of unusual movements, violent or complex behaviours, it is essential that a continuous video recording of the patient is also made that includes sound as well as high quality visual images. Modern computer-based PSG recording systems often provide the facility for time locked digital video images and sound recordings that can be overlaid on the PSG recording. This is ideal for synchronising the EEG and sleep staging with the behavioural disturbance. Where this facility is not available there should be a method of synchronising the video recording with the PSG to an accuracy of at least 10 secs.

REM behaviour disorder is characterised by absent or reduced REM-related hypotonia and by exaggerated or excessive phasic REM limb movements. To capture these changes it is recommended that, in addition to the standard submental EMG, separate EMG recordings are made from one or more postural muscles (52).

RLS/PLMS. Anterior tibialis EMG or leg motion sensors should be part of the PSG montage. The record should be scrutinised for frequent periodic movements during periods of wakefulness (RLS) as well as during sleep (PLMS). It is important to distinguish periodic limb movements from respiratory-related event limb movements. To do this a sensitive measure of upper airway obstruction and flow limitation such as continuous recording of nasal pressure is recommended. Even with this, the distinction between the two conditions can often be difficult and may be resolved only by further PSG observations once upper airway obstruction is corrected (eg by CPAP).

Seizures An expanded bilateral EEG montage should be employed, with a sufficiently high digital sampling rate to detect brief paroxysmal discharges. The computer record should be able to be displayed at 10 sec full screen resolution. It is essential that a polysomnographer and sleep physician or neurologist experienced or trained in seizure recognition be assigned to these

studies and where none is available appropriate consultation is sought or the patient referred to a centre with the appropriate expertise.

4. NON RESPIRATORY DISORDERS OF EXCESSIVE DAYTIME SLEEPINESS

4.1 INDICATIONS FOR SLEEP STUDY (5;6)

4.1.1 DIAGNOSIS OF NARCOLEPSY

The diagnosis of narcolepsy can be made confidently by history alone when the classic tetrad of daytime hypersomnolence, sleep paralysis, hypnagogic or hypnopompic hallucinations and cataplexy is present. The latter symptom, in particular, is highly specific for this disease. However, sleep studies (PSG and multiple sleep latency test (MSLT)) can be an invaluable adjunct to diagnosis particularly in cases in which a history of cataplexy is absent or equivocal. PSG is used primarily to exclude other causes of excessive daytime sleepiness (eg OSA), and is also traditionally employed as part of the MSLT protocol to confirm that the patient had sufficient sleep the night prior to the MSLT. The finding of an MSLT average sleep latency of <5 mins, in the absence of a history of chronic sleep restriction or acute sleep deprivation, and in the absence of sleep disordered breathing or RLS/PLMS on PSG is strong supporting evidence for the diagnosis of narcolepsy. The combination of sleep latency <5mins and 2 or more REM onset sleeps on MSLT is reasonably sensitive and specific for narcolepsy but still cannot be relied on alone for the diagnosis(53). If, following careful history taking and sleep testing (PSG and MSLT) there remains diagnostic uncertainty, CSF hypocretin levels might be considered (54). In atypical cases brain MRI may be useful to rule out structural brain stem lesions.

4.1.2 DIAGNOSIS OF PRIMARY HYPERSOMNIA AND OTHER RARE DISORDERS LEADING TO HYPERSOMNOLENCE

The diagnosis of primary hypersomnia is one of exclusion. PSG is therefore required to rule out common sleep disorders such as OSA that can lead to hypersomnolence. An assessment of sleep-wake schedules using a sleep diary with or without actigraphy over a 2-3 week period can also be helpful to exclude chronic sleep restriction. MSLT should be performed to objectively confirm the presence of hypersomnolence. Other rare disorders such as Prader-Willi Syndrome, Myotonic Dystrophy and Klein Levin Syndrome are associated with pathological sleepiness (and in the instance of the first two disorders, with sleep onset REMs) and may thus enter the differential diagnosis of idiopathic hypersomnia or narcolepsy. However, these conditions are usually readily identified by careful clinical history and examination, supplemented by genetic testing in some instances.

4.1.3 QUANTIFICATION AND VERIFICATION OF EXCESSIVE DAYTIME SLEEPINESS FOR MANAGEMENT PURPOSES

Objective tests of daytime sleepiness such as MSLT and the maintenance of wakefulness test (MWT) are not recommended routinely for the management of patients with sleep disorders. Response to treatment can usually be judged clinically and with the assistance of validated questionnaires such as the Epworth Sleepiness Scale. However, where there is reason to suspect this type of assessment is unreliable (eg over reporting or under reporting of symptoms by patients), and it is important to have a clear idea of the level of daytime impairment for management, driver licensing or medicolegal purposes, tests such as the MSLT and MWT may be useful. The MWT has a stronger a priori rationale as a test of daytime alertness, and may therefore be of more relevance than the MSLT to assess occupational and driving safety. There can be considerable discrepancy between MSLT and MWT findings in the same subject (55) suggesting that the two tests provide different information about sleepiness or sleep propensity.

4.2 TYPES OF SLEEP STUDY

4.2.1 POLYSOMNOGRAPHY

See sections 2.3, 2.4.1, 2.5 and 2.6 above

4.2.2 MULTIPLE SLEEP LATENCY TEST

Four to five evenly spaced 20-minute daytime nap opportunities with the patient lying in a quiet darkened room are provided and the time to sleep and REM sleep onset (if any) is quantified from EEG/ EOG and EMG recordings. The patient is instructed to attempt to fall asleep and the mean sleep latency result is taken to be indicative of sleep propensity.

4.2.3 MAINTENANCE OF WAKEFULNESS TEST

This test consists of four evenly spaced 40-minute test periods in the daytime during which the patient is asked to resist sleep while sitting comfortably in an arm chair in a darkened room. The patient must not engage in any activities prior to or during these test periods that may increase arousal levels. EEG/EOG and EMG are measured and the latency to sleep onset (if any) is quantified. The test has a stronger a priori rationale as a measure of a patient's daytime vigilance or ability to resist sleep than the MSLT.

4.2.4 OSLER TEST

The Osler test is essentially the same as the MWT with the exception that sleep onset is determined from psychomotor performance rather than EEG/

EOG and EMG (ie absence of button pressing response to a light presented at frequent regular intervals). Mean sleep latency using this test agrees closely with MWT results obtained in the same patients with sleep disorders. There is less experience in Australia and New Zealand with this test than MSLT and MWT, and fewer published reports of normal results. It has the potential advantage that it can be performed in centres that do not have a sleep laboratory. It may allow some cost savings when performed in a sleep laboratory because of reduced requirements for technician EEG real time observation and subsequent scoring.

4.3 TEST PERFORMANCE AND INTERPRETATION

4.3.1 MSLT

The reader is directed to a recent American Academy of Sleep Medicine publication for a detailed description of the performance of the MSLT, reporting of results and test interpretation (5) . Use of additional occipital leads in the EEG montage is highly desirable as the transition from wake to sleep is accompanied by loss of alpha waveforms. This transition is more accurately measured by the use of occipital leads. Measurement of respiratory parameters is not generally indicated in an MSLT.

Where an MSLT is conducted on a patient known to have a respiratory sleep disorder and using treatment, the test should be conducted with the patient using treatment, for example using CPAP. If this is not done there is a risk of prolonging sleep latency through the occurrence of respiratory events at sleep onset.

4.3.2 MWT

The reader is directed to two recent American Academy of Sleep Medicine publications for a detailed description of the performance of the MWT, reporting of results and test interpretation(5;6). Measurement of respiratory parameters is not generally indicated in a MWT. There are generally fewer normative data for the MWT than the MSLT, but some normative data for the Australian population are available(56). The MWT should not be performed with the patient using CPAP or oral appliances. The MWT is usually performed to assess the patient's ability to remain awake in a real-life situation such as driving, where the use of treatment such as CPAP would be inappropriate.

4.3.3 OSLER TEST

The reader is directed to recent publications for a detailed description of the performance of the Osler test(57;58). Because there are fewer reports and limited normative data for this test, it should probably be considered as an investigational research tool at this time.

5. INSOMNIA AND DISORDERS OF INSUFFICIENT SLEEP (59;60)

5.1 INDICATIONS FOR SLEEP STUDY

This is no evidence to support the routine use of PSG in the assessment of patients with insomnia where it appears to be psychophysiological in type or is related to a circadian sleep disorder. However, if there is a history suggestive of sleep disordered breathing, PLMS or parasomnias that might be contributing to prolonged sleep latency or disrupted sleep patterns, PSG should be considered.

5.2 SLEEP DIARY AND ACTIGRAPHY

Systematic recordings of subjective estimates of sleep and bed times made over days or weeks by patients who present with complaints of insomnia can be invaluable in assessing the nature of their insomnia (eg distinguishing delayed or advanced phase insomnia from psychophysiological insomnia) and can be useful in following response to treatment interventions. 24-hour actigraphy measurements may be used also in special circumstances to corroborate the subjective sleep reports or point to a possible problem of sleep misperception.

6. SLEEP LABORATORY FACILITIES AND PERSONNEL REQUIREMENTS

Appropriate standards for sleep laboratory facilities and personnel are detailed elsewhere, in the "Accreditation of Sleep Disorders Services" document published jointly by the TSANZ and ASA (61). These standards address requirements regarding: organization and administration; staffing and direction; policies and procedures; staff development, teaching and research; facilities; provision for emergencies; quality assurance; meetings; and the policies and procedures manual. They should be referred to in regard to these matters.

7. REFERENCE LIST

- (1) Practice parameters for the indications for polysomnography and related procedures. Polysomnography Task Force, American Sleep Disorders Association Standards of Practice Committee. *Sleep* 1997; 20(6):406-422.
- (2) Chesson AL, Jr., Anderson WM, Littner M, Davila D, Hartse K, Johnson S et al. Practice parameters for the nonpharmacologic treatment of chronic insomnia. An American Academy of Sleep Medicine report. Standards of Practice Committee of the American Academy of Sleep Medicine. *Sleep* 1999; 22(8):1128-1133.
- (3) Flemons WW, Littner MR, Rowley JA, Gay P, Anderson WM, Hudgel DW et al. Home diagnosis of sleep apnea: a systematic review of the literature. An evidence review cosponsored by the American Academy of Sleep Medicine, the American College of Chest Physicians, and the American Thoracic Society. *Chest* 2003; 124(4):1543-1579.
- (4) Littner M, Hirshkowitz M, Kramer M, Kapen S, Anderson WM, Bailey D et al. Practice parameters for using polysomnography to evaluate insomnia: an update. *Sleep* 2003; 26(6):754-760.
- (5) Littner MR, Kushida C, Wise M, Davila DG, Morgenthaler T, Lee-Chiong T et al. Practice parameters for clinical use of the multiple sleep latency test and the maintenance of wakefulness test. *Sleep* 2005; 28(1):113-121.
- (6) Kushida CA, Littner MR, Morgenthaler T, Alessi CA, Bailey D, Coleman J et al. Practice parameters for the indications for polysomnography and related procedures: An update for 2005. *Sleep* 28[4], 499-521. 2005.
- (7) Hillman D.R., Bowes G., Grunstein R.R., McEvoy R.D., Pierce R.J., Saunders N.A. et al. Guidelines for Respiratory Sleep Studies. Thoracic Society of Australia and New Zealand . 1994.
- (8) Sleep-related breathing disorders in adults: recommendations for syndrome definition and measurement techniques in clinical research. The Report of an American Academy of Sleep Medicine Task Force. *Sleep* 1999; 22(5):667-689.
- (9) Flemons WW, Douglas NJ, Kuna ST, Rodenstein DO, Wheatley J. Access to diagnosis and treatment of patients with suspected sleep apnea. *Am J Respir Crit Care Med* 2004; 169(6):668-672.
- (10) Pack AI. Sleep-disordered breathing: access is the issue. *Am J Respir Crit Care Med* 2004; 169(6):666-667.

- (11) Manser RL, Rochford P, Naughton MT, Pierce RJ, Sasse A, Teichtahl H et al. Measurement variability in sleep disorders medicine: the Victorian experience. *Intern Med J* 2002; 32(8):386-393.
- (12) Hill NS. Noninvasive ventilation. Does it work, for whom, and how? *Am Rev Respir Dis* 1993; 147(4):1050-1055.
- (13) Hukins CA, Hillman DR. Daytime predictors of sleep hypoventilation in Duchenne muscular dystrophy. *Am J Respir Crit Care Med* 2000; 161(1):166-170.
- (14) Young IH, Crockett AJ, McDonald CF. Adult domiciliary oxygen therapy: position statement of the Thoracic Society of Australia and New Zealand. *N Z Med J* 1999; 112(1080):15-18.
- (15) Chaouat A, Weitzenblum E, Kessler R, Schott R, Charpentier C, Levi-Valensi P et al. Outcome of COPD patients with mild daytime hypoxaemia with or without sleep-related oxygen desaturation. *Eur Respir J* 2001; 17(5):848-855.
- (16) Chaouat A, Weitzenblum E, Kessler R, Charpentier C, Enrhart M, Schott R et al. A randomized trial of nocturnal oxygen therapy in chronic obstructive pulmonary disease patients. *Eur Respir J* 1999; 14(5):1002-1008.
- (17) Grunstein RR, Ho KY, Sullivan CE. Sleep apnea in acromegaly. *Ann Intern Med* 1991; 115(7):527-532.
- (18) Sin DD, Fitzgerald F, Parker JD, Newton G, Floras JS, Bradley TD. Risk factors for central and obstructive sleep apnea in 450 men and women with congestive heart failure. *Am J Respir Crit Care Med* 1999; 160(4):1101-1106.
- (19) Bradley TD, Floras JS. Sleep apnea and heart failure: Part II: central sleep apnea. *Circulation* 2003; 107(13):1822-1826.
- (20) Bradley TD, Floras JS. Sleep apnea and heart failure: Part I: obstructive sleep apnea. *Circulation* 2003; 107(12):1671-1678.
- (21) Kaneko Y, Floras JS, Usui K, Plante J, Tkacova R, Kubo T et al. Cardiovascular effects of continuous positive airway pressure in patients with heart failure and obstructive sleep apnea. *N Engl J Med* 2003; 348(13):1233-1241.
- (22) Hukins C. Comparative study of autotitrating and fixed-pressure CPAP in the home: a randomized, single-blind crossover trial. *Sleep* 2004; 27(8):1512-1517.
- (23) Masa JF, Jimenez A, Duran J, Capote F, Monasterio C, Mayos M et al. Alternative methods of titrating continuous positive airway pressure: a large multicenter study. *Am J Respir Crit Care Med* 2004; 170(11):1218-1224.
- (24) Hukins CA. Arbitrary-pressure continuous positive airway pressure for obstructive sleep apnea syndrome. *Am J Respir Crit Care Med* 2005; 171(5):500-505.

- (25) Redline S, Sanders MH, Lind BK, Quan SF, Iber C, Gottlieb DJ et al. Methods for obtaining and analyzing unattended polysomnography data for a multicenter study. Sleep Heart Health Research Group. *Sleep* 1998; 21(7):759-767.
- (26) Quan SF, Griswold ME, Iber C, Nieto FJ, Rapoport DM, Redline S et al. Short-term variability of respiration and sleep during unattended nonlaboratory polysomnography--the Sleep Heart Health Study. *Sleep* 2002; 25(8):843-849.
- (27) Iber C, Redline S, Kaplan Gilpin AM, Quan SF, Zhang L, Gottlieb DJ et al. Polysomnography performed in the unattended home versus the attended laboratory setting--Sleep Heart Health Study methodology. *Sleep* 2004; 27(3):536-540.
- (28) Executive summary on the systematic review and practice parameters for portable monitoring in the investigation of suspected sleep apnea in adults. *Am J Respir Crit Care Med* 2004; 169(10):1160-1163.
- (29) Chesson AL, Jr., Berry RB, Pack A. Practice parameters for the use of portable monitoring devices in the investigation of suspected obstructive sleep apnea in adults. *Sleep* 2003; 26(7):907-913.
- (30) Flemons WW, Littner MR. Measuring agreement between diagnostic devices. *Chest* 2003; 124(4):1535-1542.
- (31) Elshaug AG, Moss JR, Southcott AM. Implementation of a split-night protocol to improve efficiency in assessment and treatment of obstructive sleep apnoea. *Intern Med J* 2005; 35(4):251-254.
- (32) Rodway GW, Sanders MH. The efficacy of split-night sleep studies. *Sleep Med Rev* 2003; 7(5):391-401.
- (33) Farre R, Montserrat JM, Ballester E, Hernandez L, Rotger M, Navajas D. Importance of the pulse oximeter averaging time when measuring oxygen desaturation in sleep apnea. *Sleep* 1998; 21(4):386-390.
- (34) Strohl KP, House PM, Holic JF, Fouke JM, Cheung PW. Comparison of three transmittance oximeters. *Med Instrum* 1986; 20(3):143-149.
- (35) West P, George CF, Kryger MH. Dynamic in vivo response characteristics of three oximeters: Hewlett-Packard 47201A, Biox III, and Nellcor N-100. *Sleep* 1987; 10(3):263-271.
- (36) Barker SJ. "Motion-resistant" pulse oximetry: a comparison of new and old models. *Anesth Analg* 2002; 95(4):967-72, table.
- (37) Pittman SD, MacDonald MM, Fogel RB, Malhotra A, Todros K, Levy B et al. Assessment of automated scoring of polysomnographic recordings in a population with suspected sleep-disordered breathing. *Sleep* 2004; 27(7):1394-1403.

- (38) Rechtschaffen A, Kales A. A manual of standardized terminology, techniques and scoring system for sleep stages of human subjects. Los Angeles: Brain Information Service/Brain Research Institute, University of California at Los Angeles. 1968.
- (39) EEG arousals: scoring rules and examples: a preliminary report from the Sleep Disorders Atlas Task Force of the American Sleep Disorders Association. *Sleep* 1992; 15(2):173-184.
- (40) Whitney CW, Gottlieb DJ, Redline S, Norman RG, Dodge RR, Shahar E et al. Reliability of scoring respiratory disturbance indices and sleep staging. *Sleep* 1998; 21(7):749-757.
- (41) Kristo DA, Lettieri CJ, Andrada T, Taylor Y, Eliasson AH. Silent upper airway resistance syndrome: prevalence in a mixed military population. *Chest* 2005; 127(5):1654-1657.
- (42) Hosselet JJ, Norman RG, Ayappa I, Rapoport DM. Detection of flow limitation with a nasal cannula/pressure transducer system. *Am J Respir Crit Care Med* 1998; 157(5 Pt 1):1461-1467.
- (43) Ayappa I, Norman RG, Krieger AC, Rosen A, O'malley RL, Rapoport DM. Non-Invasive detection of respiratory effort-related arousals (RERas) by a nasal cannula/pressure transducer system. *Sleep* 2000; 23(6):763-771.
- (44) Guilleminault C, Stoohs R, Clerk A, Cetel M, Maistros P. A cause of excessive daytime sleepiness. The upper airway resistance syndrome. *Chest* 1993; 104(3):781-787.
- (45) Douglas NJ. Upper airway resistance syndrome is not a distinct syndrome. *Am J Respir Crit Care Med* 2000; 161(5):1413-1416.
- (46) Young T, Blustein J, Finn L, Palta M. Sleep-disordered breathing and motor vehicle accidents in a population-based sample of employed adults. *Sleep* 1997; 20(8):608-613.
- (47) Young T, Peppard P, Palta M, Hla KM, Finn L, Morgan B et al. Population-based study of sleep-disordered breathing as a risk factor for hypertension. *Arch Intern Med* 1997; 157(15):1746-1752.
- (48) Barnes M, McEvoy RD, Banks S, Tarquinio N, Murray CG, Vowles N et al. Efficacy of positive airway pressure and oral appliance in mild to moderate obstructive sleep apnea. *Am J Respir Crit Care Med* 2004; 170(6):656-664.
- (49) Engleman HM, Kingshott RN, Wraith PK, Mackay TW, Deary IJ, Douglas NJ. Randomized placebo-controlled crossover trial of continuous positive airway pressure for mild sleep Apnea/Hypopnea syndrome. *Am J Respir Crit Care Med* 1999; 159(2):461-467.

- (50) Redline S, Adams N, Strauss ME, Roebuck T, Winters M, Rosenberg C. Improvement of mild sleep-disordered breathing with CPAP compared with conservative therapy. *Am J Respir Crit Care Med* 1998; 157(3 Pt 1):858-865.
- (51) Effectiveness of nasal continuous positive airway pressure (nCPAP) in obstructive sleep apnea in adults. National Health and Medical Research Council . 2000. Commonwealth of Australia, AusInfo.
- (52) Consens FB, Chervin RD, Koeppe RA, Little R, Liu S, Junck L et al. Validation of a polysomnographic score for REM Sleep Behavior disorder. *Sleep* 28[8], 993-997. 2005.
- (53) Aldrich MS, Chervin RD, Malow BA. Value of the multiple sleep latency test (MSLT) for the diagnosis of narcolepsy. *Sleep* 1997; 20(8):620-629.
- (54) Mignot E, Chen W, Black J. On the value of measuring CSF hypocretin-1 in diagnosing narcolepsy. *Sleep* 2003; 26(6):646-649.
- (55) Sangal RB, Thomas L, Mitler MM. Maintenance of wakefulness test and multiple sleep latency test. Measurement of different abilities in patients with sleep disorders [see comments]. *Chest* 1992; 101(4):898-902.
- (56) Banks S, Barnes M, Tarquinio N, Pierce RJ, Lack LC, McEvoy RD. The maintenance of wakefulness test in normal healthy subjects. *Sleep* 2004; 27(4):799-802.
- (57) Bennett LS, Stradling JR, Davies RJ. A behavioural test to assess daytime sleepiness in obstructive sleep apnoea. *J Sleep Res* 1997; 6(2):142-145.
- (58) Krieger AC, Ayappa I, Norman RG, Rapoport DM, Walsleben J. Comparison of the maintenance of wakefulness test (MWT) to a modified behavioral test (OSLER) in the evaluation of daytime sleepiness. *J Sleep Res* 2004; 13(4):407-411.
- (59) Practice parameters for the use of polysomnography in the evaluation of insomnia. Standards of Practice Committee of the American Sleep Disorders Association. *Sleep* 1995; 18(1):55-57.
- (60) Chesson A, Jr., Hartse K, Anderson WM, Davila D, Johnson S, Littner M et al. Practice parameters for the evaluation of chronic insomnia. An American Academy of Sleep Medicine report. Standards of Practice Committee of the American Academy of Sleep Medicine. *Sleep* 2000; 23(2):237-241.
- (61) Accreditation of Sleep Disorders Services - Standards and Guidelines. Thoracic Society of Australia and New Zealand/Australasian Sleep Association. 1997.

8. APPENDIX

The following conflicts or potential conflicts of interest were declared by members of the committee

1. Current or recent (last 3 years) Involvement with company or companies with a financial interest in devices or methods for performing sleep studies
 - a. Direct financial interest (PS, ST)
 - b. Employee, or engaged in a consulting capacity (including medical advisory boards, expert testimony) (DH)
 - c. Substantial research support (GC, MH, RDMc, AN, PS, HT)
 - d. Sponsored attendance at national or international meetings (Nil)

2. Financial benefit received (personally, spouse or dependents, or department) from performing or reporting sleep studies*
 - a. Direct benefit received (RDMc, HT, PS, ST, BT)
 - b. Departmental benefit received (AN, GC, MD, RDMc, HT, PS)

Individual COI statements are available from the secretariats of the Australasian Sleep Association and the Thoracic Society of Australia and New Zealand

* In all cases the predominant type of sleep study for which benefit was derived was full PSG